

Hand-Held Computing in the Patient Care Setting: A Pilot Project

Judith F. Karshmer, R.N., Ph.D.* & Arthur I. Karshmer, Ph.D.°

Department of Nursing*
Department of Computer Science°
New Mexico State University
Las Cruces, NM 88003 USA
jkarshme@cc.nmsu.edu

arthur@cs.nmsu.edu (<http://www.cs.nmsu.edu/~arthur/>)

Direct patient care has not fully benefited from a number of recent advances in modern technology. Many of the normal data collections tasks carried out by care providers are still done with manual, error-prone procedures. In addition, the ability to consolidate or represent patient data in a meaningful and timely fashion as required by managed care expectations is unavailable. The reported work attempts to address these problems with the application of new hand-held computing technology.

INTRODUCTION

The complexity of health care in the hospital setting is rapidly outstripping the practitioner's ability to manage and document that care in any adequate or useful fashion. The nurse in particular must collect a myriad of on-going assessment data. With the advent of managed care the nurse is also responsible for assuring that projected treatments and expected outcomes follow a specified time-frame. In all but the most advanced and well financed institutions, in the majority of community hospitals, these data are collected by hand-written nurses notes. While many hospitals have partially replaced narrative nurses' notes with flow-sheets and check lists, or have worked to implement streamlined processes through computerization with centrally placed terminals for keyboard entry, the fact remains that the initial entry of most patient information at the bedside is done by hand. Whereas other departments in the hospital such as lab and x-ray have fully embraced the use computers for data entry as well as analysis, nursing has fallen far behind even the most rudimentary use of computer assisted documentation. While a number of demonstration projects for computerized nurses' notes have been designed, they are far too costly, physically cumbersome, both in size and flexibility, and most significantly, so far removed from the needs of the nurse in ongoing patient care documentation, to be practical (cf. Evans, 1990; Herbst, 1989; Ball & Hannah, 1988; Halford, Pryor, & Burkes 1987; Giovannetti, 1985).

It is essential that health care delivery take full advantage of emerging computer-based patient manage-

ment systems. In particular, a number of real time nurse-patient situations would profit from application of contemporary computer technology to managing patient care (National Institute of Nursing Research, 1993; Anderson, 1994; ANA, 1993; IOM, 1991; Gabler, 1990; Graves, & Corcoran, 1988).

- Patient care has become so complex and the nurse so rushed for time, a great deal of pertinent patient information is not documented (Hendrickson & Kovner, 1990).
- Even in the situations when all the crucial patient information is recorded by the nurse on the nurses' notes, there exists a distinct possibility that the information may never reach the patients's chart for the doctor's use in a timely or accurate fashion. Data collected at the bedside or during a treatment is often scribbled on a scrap of paper and "officially" recorded at some later time. On each occasion these data are re-charted, there exists the possibility for error or omission which may lead to negative consequences for the patient (Staggers, 1988).
- One of the physician's biggest headaches is having the information when s/he needs it. If the nurse waits until the end-of-shift to chart, crucial data may not be available. If, on the other hand, the nurse keeps the chart with him/her during the shift in order to make immediate entry of information, it is not accessible to the doctor when s/he needs it (Johnson, Burkes, Sittig, Hinson, & Pryor, (1987).
- In order for certain information to be useful it has to be graphed to show trends over time. Four times daily blood glucose levels or periodic weight changes need to be graphed. For information to be available in this form, the nurse must keep a second, even sometimes third, patient record that has been specifically designed to cluster data about a patient for a particular physician's needs. Not only does the loss of accuracy becomes significant with so much "double and triple" charting, but there is a costly negative effect on the nurses' time.
- Many hospitals initiated computerized documenta-

tion for medication administration long ago. Nurses verify that medications have been administered and pharmacy bills patients and charges accordingly. Although efficient for the pharmacy, this approach is not designed to facilitate ease of charting for the nurse. In fact, the process merely adds a step. In addition to the pharmacy code sheet, the nurse must verify the doctor's orders, make an entry on the patient's chart that the medication was administered, and record the therapeutic effect it had on the patient. All of these manual entries must be made on different documents, often in different locations. This is another significant example how repetitive, time-consuming charting is costly as well as error prone and incompatible with recognized standards for data transmission (HL-7 Working Group, 1988).

- In addition to being responsible for providing and documenting care, the nurse is also expected to charge patients for supplies. These charges may range from the use of a complex specialty bed to each time a patient has an I.V. start, change of tubing, or requires a box of tissues. Many hospitals have a "sticker" system in which the nurse removes a coded sticker and affixes it to a specific patient "charge sheet". Some items are "unit supplies" and must be charged to the unit. During the course of care the nurse all too often sticks the "stickers" to her/his uniform with the intention of eventually placing them on the correct charge sheet. As one can well imagine the "stickers" often get lost. The resulting inaccuracies are costly to the patient, the hospital, and prohibit any truly accurate inventory system (Gabler, 1990; Greer & Hexum, 1987).
- Home-health is another area to profit from the use of a streamlined computerized documentation system. A number of home health agencies have begun to utilize the lap-top computer for nurses to document their visits. However, they are less than ideal..

These are only a few examples of the inefficient documentation methods that would directly benefit from the introduction of contemporary computer technology with total database management.

CURRENT TECHNOLOGIES

Currently the ability to collect patient data has been hampered by two factors. First, while various current technologies possess interesting and useful tools, no one technology has all of the elements needed in such a data collection system. For example machines such as the Macintosh Powerbooks afford a level of portable systems with good user interfaces, but they tend to be too large to be useful by the health provider on the floor. Carrying a "lap-top" at all times for data entry is just too cumbersome. Another group of systems characterized by the HPxxxLX and the Zeos

Pocket PC are approximately the correct size, they do not possess the interface appropriate to the task.

Second, even the best icon driven interfaces don't closely enough approximate the manner in which health professionals prefer to collect data. Use of such systems, even were they the appropriate size, would require substantial retraining of already over-stressed health care providers. One sure way to assure that a documentation system will be unsuccessful is to require the modifications be made by the practitioners rather than the system (Kaplan, 1994). Finally, even the best user interfaces require data input from traditional QWERTY keyboards: a method not consistent with normal medical practice in the patient care environment on the hospital floor. Switching between normal nursing tasks and typing tasks is not productive.

A SOLUTION

Manufacturers such as Apple (the Newton), AT&T (the EO) and General Magic (the Magic Machine), to name a few, are now introducing palm-sized, high-powered, pen-based systems that cost less than \$1,000. These systems are capable of collecting patient data on site, in a meaningful manner, for later transfer to a host database server system on the floor, that in turn could be a node in a complete hospital information system.

The development system, which is implemented on an Apple Newton MessagePad, addresses a number of currently unacceptable features inherent in providing and documenting nursing care in the hospital. Use of a light-weight, hand-held device that fits into a "holster" can provide a method for data entry at the bedside and allow transfer of that data to a host database server at the nurses' station. The nurse only needs to enter information once and as a result that information is more likely to be accurate as well as available. Further, the system checks all entered data against previous patient values as well as normal ranges. When discrepancies are found, the nurse is immediately advised (see figure 1). Once collected on the hand-held device, information can be immediately transferred via a built-in infrared network transceiver to a base-unit at the nurse's station or a central information system in the hospital. Each patient room would be wired with an inexpensive infrared transceiver for accepting and delivering information to the health provider. Such systems are extremely robust, with handshaking protocols that will not allow flawed data to be transferred in either direction. While there is no completely error-free protocol, the error rate is so low as to be considered non-existent. In the worst case, it is infinitely lower than the error-rate associated with human transmission.

The same hand-held unit can also be used by phy-

The screenshot shows a handheld device interface with the following elements:

- Top Section:** Two boxes for patient data. The left box is labeled 'Temp' and shows 'F° 100.6' and 'C° 38.1'. The right box is labeled 'Weight' and shows 'lbs 238.3' and 'Kg 108.3'.
- Warning Box:** A central box with a jagged border containing the text:
 - Ⓢ Warning
 - Patient Temp. out of normal range [98.6]
 - Patient Temp. not consistent with previous value [98.0]
 - A close button (X) in the bottom right corner.
- Bottom Section:** Two boxes for 'Out' (72) and 'Wt' (6.5). Below these is a 'Function Temperature' slider with a diamond marker. To the right of the slider are up and down arrow buttons.
- Input Mode:** A section labeled 'Input Mode Right Hande' with a close button (X). Below it are icons for 'Names', 'Dates', 'Extras', 'Undo', 'Find', and 'Assist'.

Figure 1 - Error Reporting

sicians and other professionals while making rounds. In place of carrying the normal patient chart, the hand-held device can serve the traditional chart function, plus much more. In the current health care climate nurses and physicians are working toward a responsible managed care environment. The most contemporary approaches use "critical paths" or "care maps." These are well researched, interdisciplinary "guide-line" for what should be done and when, for a category of patient problems, and/or diagnostic groups. The most sophisticated of these "care maps" serve as general directions, an individualized plan, and as the documentation tool itself. It is this format that is the basis for the development system in a virtual form on the hand-held device. When a patient is admitted the nurse and physician complete an initial history and physical using a somewhat traditional intake form. With this information, they decide which critical path to use. This "path," which is stored in the hand-held device, is activated by the nurse, who individualizes it for the specific patient as directions scroll through the screen. Depending on the critical path and the related physician orders which are used to individualize a "path,"

the nurse is directed to complete ongoing assessments at specified times, arrange for treatments, attend to activities of daily living, progress a diet, engage in patient/family teaching, administer medications, assure that laboratory work is completed, and attend to the discharge needs of the patient.

A critical path in the hand-held, palm-sized system, directs the nurse to make regular patient rounds collecting information on the *virtual* forms that are displayed on the hand-held system. Using these *live forms* that request assessment and key diagnostic information required by a specific care map, the nurse enters data in a familiar manner using scales and coded options. Each input is automatically checked for deviations from the patient's previous status as well as against the "correct range". When an input is different from a patient's previous value or out-side the normal range, this is indicated. The nurse is able to re-check a measurement or make note of the change or deviation.

Except for items that take the form of written notes, all data are collected in a convenient point and pick format. Written notes can be entered in handwritten form and stored as *electronic ink*. Accuracy of data collection will be improved on several levels. For example, the hand-held system will have a UPC scanner to get patient ID from the patient's wrist band and care-provider information from the employee's badge. Figures 1 and 2 show views of one page of input and the tools associated with it (The figures are *electronic snapshots* of the actual Newton screen).

On the current page of the Newton we see information areas for a variety of data to be collected. By tapping one of the boxes with the stylus, the nurse makes that the active element. Then, using either a slider and arrows as shown in figure 1, or a keypad as shown in figure 2, s/he can enter the appropriate data¹. When double-view data are entered, such as temperature and weight, via a slider, conversions are automatically made on a continuous basis as the slider is moved. The up and down arrows are used to input fractional data. When a keypad is used, the nurse is allowed to specify which measurement system is being used. Once entered, all data are converted to their mirror form.

After all data for a particular patient are collected, the nurse simply points her device toward a sensor in the wall of the patient's room. On a simple command to the Newton, the data are then transferred via infrared signal to the central computer for storage, analysis and distribution. All transmitted data are checked for

1. Note that left- and right-handed sliders are available as well as a telephone and adding machine keypads.

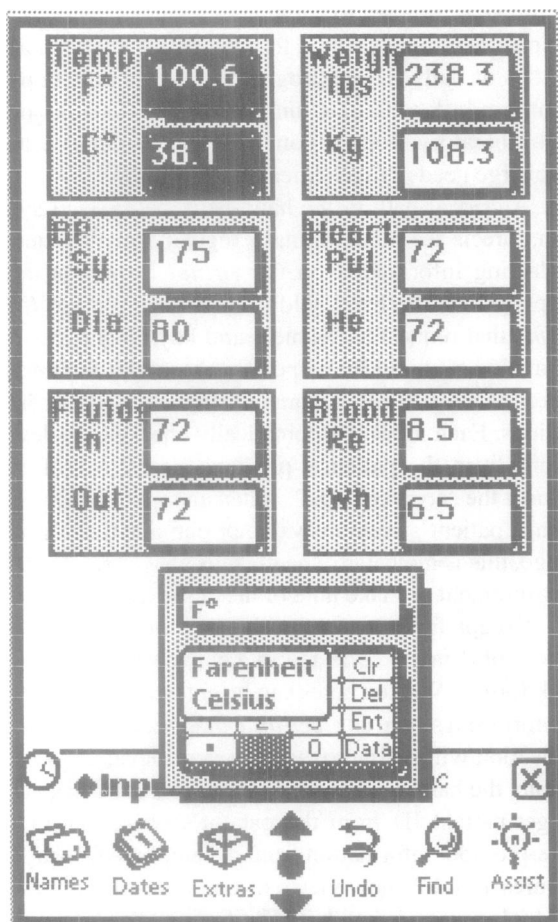


Figure2 - Tool Layout

transmission error and when correctly received, the nurses hand-held system notifies her that the transmission is complete. On error detection, the nurse is requested to transmit again.

DATA DISTRIBUTION

Management of a patient's hospitalization and monitoring length of stay as directed by a care map requires current and easily accessible patient information. A key feature of any of the care maps is time. Many care maps have a very small tolerance for time. For example, the critical path for a normal vaginal delivery allows only 16 - 24 hours from delivery to discharge for the patient to rest and recover and for the nurse to provide care for mother and baby, troubleshoot any problems that may occur post delivery, and make sure that a huge amount of teaching takes place from how to breast feed to common childhood diseases or sibling rivalry. Without accurate and timely information, the nurse may repeat information or miss it altogether and continuity of care is compromised. With the hand-held device and the transfer of information to the host computer, the nurse, physician, or other health care professional has access to all information.

Any hand-held device can retrieve from the base unit all the data for any given patient. The status of a patient's progress vis a vis a critical path can be evaluated at any time by any number of key health professionals (Figure 3).

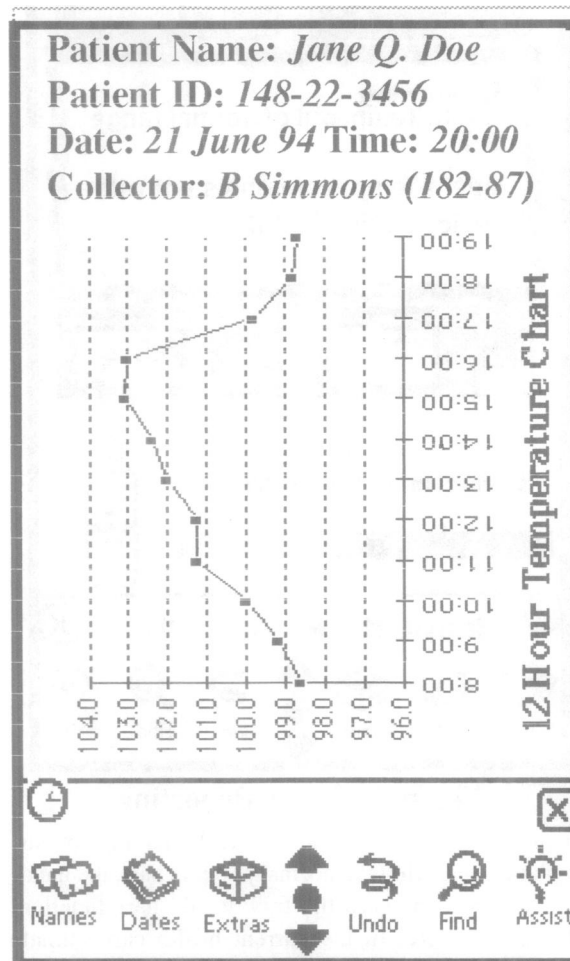


Figure 3 - Patient Data Display

PROJECT STATUS

At the current time, there is on-going development of the critical paths for six specific diagnostic related groups including two medical diagnoses, diabetes and asthma, two surgical episodes, total hip replacement and ostomy surgery, one emotional disorder, major depression, and one "healthy category," spontaneous vaginal delivery. In order to evaluate the usefulness and accuracy of the care paths, they are being piloted using the traditional paper pencil format. Once refined they will be translated to the virtual form for the development system.

Patient screens as shown in the previous figures have been implemented on a Newton MessagePad 110 system using the Newton Toolkit which is a powerful object oriented programming environment and debugger that runs on the Macintosh family of computers. As

the care maps are readied, they will be the basis for field testing.

The six care maps will be initiated in the hospital and continued as specified by the map in the home health environment. Once activated each will use appropriate methodologies to collect the data and evaluate the approach (Kaplan, 1994; Frame, Zimmer & Eberly, 1994; Gabler, 1990; Herbst, 1989; Thomas, 1988; Johnson, Burkes, Sittig, Hinson, & Pryor, 1987).

CONCLUSIONS

Cost-effective and accurate data collection and dissemination are critical in the managed care environment. Technologies currently exist to achieve these goals without having a negative impact on care provider morale. The development system offers advantages to data collectors as well as users of those data at a cost that is low now and will get even lower in the future.

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